DOCUMENT RESUME

ED 172 322 EA 011 647

TITLE	School Calendars and Energy Use. Technical Report No. 3 of a Study of School Calendars. A Study of the Energy Implications of Nine School Calendars in "Typical" New York State Elementary Schools.
INSTITUTION	Educational Facilities Labs., Inc., New York, N.Y.; New York State Education Dept., Albany. Div. of Research.
SPONS AGENCY	Albany-Schoharie-Schenectady Board of Cooperative Educational Services, Albany, N.Y.
PUB DATE	May 78
NOTE	54p.; For related documents, see EA 011 645-651; Some appendices may not reproduce clearly
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Climatic Factors; Computer Programs; Elementary Education; *Energy Conservation; Extended School Day; Extended School Year; *Fuel Consumption; School Buildings; *School Calendars; *School Schedules; *Simulation; Year Round Schools
IDENTIFIERS	New York

ABSTRACT

This study, the third in a series of reports, is limited to an analysis of the energy use and cost implications of nine school calendars proposed by the New York State Department of Education. These calendars are characterized as (1) traditional; (2) ten-month school year; (3) mid-August start, two semesters; (4) four-day week; (5) four-day, 7.5 hours; (6) four- and five-day weeks; (7) twelve-month, multiple variations; (8) five eight-week learning periods; and (9) 45-15 rotation. The factors of daily weather, schedule of operation, and building characteristics were combined to simulate the actual operation of the typical school in each climate for each calendar. The magnitude of the variations was small with only the four-day, 7.5 hour calendar producing more than a 10 percent change in all four climates. Given the slight differences between the various calendars observed, the study concludes that it would be difficult to make a strong case for one calendar over the others on the basis of its energy saving potential. (Author/MLF)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED1723322

SCOPE OF INTEREST NOTICE
The ERIC Facility has assigned this document for processing to: EA | SE
In our judgement, this document is also of interest to the clearinghouses noted to the right. Indexing should reflect their special points of view.

SCHOOL CALENDARS AND ENERGY USE

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Technical Report No. 3

of

A Study of School Calendars
Conducted for the Board of Regents
of the State of New York

for

The Division of Research

by

Educational Facilities Laboratories

in Conjunction with

The Board of Cooperative Educational Services
Albany, Schoharie and Schenectady Counties

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
J. Miller
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Albany, New York 12234

EA 011 647

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of The University (with years when terms expire)

1981	Theodore M. Black, A.B., Litt.D., LL.D., Pd.D., D.C.L., L.H.D. Chancellor	Sands Point
1988	Willard A. Genrich, LL.B., L.H.D., LL.D. Vice Chancellor	Buffalo
1986	Kenneth B. Clark, A.B., M.S., Ph.D., LL.D., L.H.D., D.Sc.	Hastings on Hudson
1983	Harold E. Newcomb, B.A.	Owego
1982	Emlyn I. Griffith, A.B., J.D.	Rome
1983	Mary Alice Kendall, B.S.	Rochester
1984	Jorge L. Batista, B.A., J.D., LL.D.	Bronx
1982	Louis E. Yavner, LL.B.	New York
1979	Laura Bradley Chodos, B.A., M.A.	Vischer Ferry
1980	Martin C. Barell, B.A., I.A., LL.B.	Kings Point
1981	Joseph R. Bongiorno, B.S., M.D.	Brooklyn
1984	Louise P. Matteoni, B.A., M.A., Ph.D.	Bayside
1981	J. Edward Meyer, B.A., LL.B.	Chappaqua
1985	Arlene B. Reed-Delaney, B.A., M.D.	Albany
1987	R. Carlos Carballada, B.S.	Arcade

President of The University and Commissioner of Education
Gordon M. Ambach

Executive Deputy Commissioner of Education
Joseph J. Blaney

Deputy Commissioner for Elementary, Secondary and Continuing Education
Robert R. Spillane

Director, Division of Research
Carl E. Wedekind

ACKNOWLEDGEMENTS

The Division of School Facilities Planning has been working for several years with Educational Facilities Laboratories, Inc. (EFL) to devise a computerized system of determining proper energy use in school buildings. Thus, it was only natural to use the expertise of the EFL staff to simulate probable energy use as if schools operated under each of the calendars. Educational Facilities Laboratories (EFL) staff worked closely with Gerald H. Wohlferd and C. Stanton Baltzel to set up this study. The following document is their report to the calendar study.

Albany-Schoharie-Schenectady Board of Cooperative Educational Services cooperated in servicing the contract with EFL. The efforts of Alan Green, President, John R. Boice, Project Administrator, Joshua A. Burns, Technical Director, and Steve Bedford, Research Associate, all of EFL, are appreciated. They proved not only a pleasure to work with, but also competent consultants.

Carl E. Wedekind, Director
Division of Research

SCHOOL CALENDARS AND ENERGY USE
A STUDY OF THE ENERGY IMPLICATIONS OF NINE SCHOOL CALENDARS IN "TYPICAL" NEW YORK STATE ELEMENTARY SCHOOLS

Prepared For The

BOARD OF COOPERATIVE EDUCATIONAL SERVICES OF
ALBANY, SCHOHARIE AND SCHENECTADY COUNTIES

By

EDUCATIONAL FACILITIES LABORATORIES, INC.

May 1978

TABLE OF CONTENTS

		Page
LIST OF TABLES AND FIGURES		vii
LIST OF EXHIBITS		viii
EXECUTIVE SUMMARY		ix
CHAPTER:		
I	INTRODUCTION	1
	Background	1
	The Purpose of the Study	2
	Tasks	2
	The Project Team	3
II	SELECTION OF THE SAMPLE SCHOOL	4
	EFL Data Base	4
III	COMPUTER SIMULATION OF THE CALENDARS	8
	Introduction	8
	Daily Weather Data and Selection of Climates	9
	Preparing the Nine Calendars for Processing	10
	Daily Activity Schedule	11
	Plant Operating Assumptions	11
	School Plant Energy Use Factors	12
IV	RESULTS OF THE COMPUTER SIMULATIONS	14
	Adding Cooling to the Typical School	19
V	OBSERVATIONS	21
	Calendar Effects on Energy Use in Other Elementary Schools Types	21
	Effect of Calendar Changes in High Schools	22
	Some Final Observations	22

LIST OF TABLES

TABLE		Page
I	Characteristics of the Typical E20 School	6
II	A Comparison of Actual and Derived Model Schools	7
III	New York Weather Stations Used in Simulations	10
IV	Energy Use Comparisons of Nine Proposed Calendars in Four New York Climates	15
V	Energy Cost Comparison of Nine Proposed Calendars in Four New York Climates	16
VI	Percentage Variation From Traditional Calendar Energy Usage in Four New York Climates	17
VII	Percentage Variation From Traditional Calendar in Per Pupil Energy Costs in Four New York Climates	18

LIST OF FIGURES

FIGURE		Page
1	PSECS Generic Type Descriptions	5

LIST OF EXHIBITS

APPENDIX		Page
A.	Calendar #1 - Conventional School Calendar	25
B.	Calendar #2 - Ten Month School Year	26
C.	Calendar #3 - Mid-August Start, Two Semesters	27
D.	Calendar #4 - Four Day Week	28
E.	Calendar #5 - Four Day Week 7.5 Hour Day	29
F.	Calendar #6 - Four and Five Day Weeks	30
G.	Calendar #7 - 12 Month, Multiple Variations	31
H.	Calendar #8 - Five Eight Week Learning Periods	32
I.	Calendar #9 - 45-15 Rotation	33

SCHOOL CALENDARS AND ENERGY USE
A STUDY OF THE ENERGY IMPLICATIONS OF NINE SCHOOL
CALENDARS IN "TYPICAL" NEW YORK STATE ELEMENTARY SCHOOLS

EXECUTIVE SUMMARY

This study is one part of a larger calendar study being conducted at the request of the New York State Regents. The scope of this study is limited to an analysis of the energy use and cost implications of nine school calendars proposed by the New York State Department of Education. Briefly these calendars may be characterized as follows:

- #1 Traditional
- #2 Ten Month School Year
- #3 Mid-August Start, Two Semesters
- #4 Four Day Week
- #5 Four Day, 7.5 Hours
- #6 Four and Five Day Weeks
- #7 12 Month - Multiple Vacations
- #8 5 Eight Week Learning Periods
- #9 45-15 Rotation

The basic task in this study was to determine the amount of energy required to operate a "typical" elementary school in each of four climates using the nine operating schedules or calendars.

SELECTION OF THE "TYPICAL" SCHOOL

To determine the physical characteristics of a typical New York elementary school, EFL examined 218 New York elementary schools that had been processed as a part of the Public Schools Energy Conservation Service (PSECS).

These schools were first separated into classes using the EFL generic classification system, a system that relies principally on age as a determinant of class. The E20 generic class was selected for study as being representative of a large number of New York schools. These schools are of the postwar finger plan type, completed between 1945 and the present, have double loaded corridors with hot water boilers and unit ventilators.

A composite typical school was derived from a study of the 102 E20 schools in the data base. An actual school matching the composite school's characteristics was then selected to serve as the validation model for computer simulation.

SELECTION OF THE CLIMATE REGIONS

In order to determine the effect of climate on operating costs and energy use, four climates were selected using the thirty-year averages provided by the National Weather Service. The average number of heating degree days per year in New York State was found to be 6,988, with a maximum of 9,169 and a minimum of 4,848. To cover this range, EFL selected three stations, Bedford (5,732), Albany (6,888), and Massena (8,237). Since all of these stations were in the eastern portion of the State, Buffalo (6,927), was added to make a fourth location. A typical year for each station was then selected, and the daily weather for that year used in the computer simulation.

SIMULATION OF THE "TYPICAL" SCHOOL

Using both the EFL Guideline Analysis Program Three (GAP3) and the Monthly Comparison Report One (MCR1), the factors of daily weather, schedule of operation and building characteristics were combined to simulate the actual operation of the typical school in each climate for each calendar.

THE RESULTS

As expected, the use of fuel oil varied in response to the severity of the climate. The difference being about 38 percent

from warmest (Bedford), to the coldest (Massena), for the traditional schedule.

With the exception of calendar #9, the year-round 45-15 plan, all of the variations from the traditional calendar showed some energy and cost savings. The magnitude of these variations, however, is small with only calendar #5 producing more than a ten per cent change in all four climates. The advantage of calendar #5 comes as the result of using the plant fewer but longer days. A comparison of energy costs for each of the calendars is shown in Table I.

Calendar #9, the 45-15 plan, is the most efficient on a per pupil basis, if the plant is assumed to house 800 students per year, rather than the 600 served with the other calendars.

If air conditioning is included in the 45-15 school, the total energy costs are 23.3 per cent above the traditional calendar for the average climate (Albany). This option was not studied for other calendars, as very few New York elementary schools are air conditioned.

CONCLUSIONS

EFL's experience suggests that the variations in energy use from calendar to calendar are too small to be significant. It has been our experience that, under actual operating conditions, similar buildings will vary far more than the differences obtained in this study, simply as a result of operating procedures and management expertise.

Given the slight differences between the various calendars observed in this study, it would be difficult to make a strong case for one calendar over the others on the basis of its energy saving potential.

TABLE I

ENERGY COST COMPARISON OF NINE PROPOSED CALENDARS

IN FOUR NEW YORK CLIMATES

Calendar	Albany	Bedford	Buffalo	Massena
#1 Traditional	$ 19213	$ 17997	$ 19011	$ 20871
#2 Ten-month Year	19051	17820	18844	20545
#3 Mid-August Start	19007	17683	18771	20461
#4 Four-day Week	18581	16908	18345	19978
#5 Four 7.5 Hour Days	17110	16908	18345	18516
#6 Four and Five Day	18346	17186	18150	19873
#7 Twelve-month Year	18761	17582	18538	20282
#8 Five Instr. Periods	18585	17369	18453	20063
#9 45-15 Rotation	22488	21286	22276	24022
#9 45-15 Rotation Air Cond.	24005			

Cost estimates based on electrical cost of $0.05 per KWH, #4 fuel oil at $0.40 per gallon.

CHAPTER I

INTRODUCTION

BACKGROUND

New York school districts, like most school districts in the country, are experiencing the adverse effects of rapidly increasing energy costs on operating budgets and instructional programs. In a State where energy costs are considerably above the National average, and the climate more extreme, it is extremely important to explore all possible means of reducing energy use that are compatible with educational program requirements.

Energy use in schools is the result of a combination of three factors:

- the physical characteristics of the facility
- the building's use pattern
- the climate

Short of moving the building to a more benign climate, nothing can be done to affect the climate in which the building operates. The other two factors are, however, under the control of the school district to some degree. Improvements to the physical plant and its operation continue to be the focus of the energy conservation efforts of most school districts.

The potential for saving energy through various scheduling arrangements has received little attention, and even less actual research effort.

Proponents and opponents of various alter ative school calendars debate the impact of each, primarily from social, educational or personal viewpoints.

There are, however, important energy implications for such schedules that have yet to be examined in an objective manner. While energy use may not be the most important factor in the decision to use one or another calendar, it must receive increasing consideration, as energy costs continue to take larger and larger portions of the school budget.

THE PURPOSE OF THE STUDY

The purpose of this study is to provide basic information on energy cost and consumption implications of nine school calendars proposed by The New York State Education Department.

TASKS

In order to accomplish the purpose of this study, the following tasks were specified:

- determine the characteristics of a typical New York State elementary school
- describe the elementary school in terms of information in EFL's data collection form to include; but not to be limited to size, type, program, area of glass, type of construction, heating system and number of students
- construct a computer model of the operation of the typical elementary school
- validate the model, using actual school data
- simulate operation of the typical elementary school under each of the nine calendars being studied by the Division of Research of the New York State Education Department, as if operating in each of three climate zones found in New York State
- determine energy use, including cooling when applicable, under each calendar type in each climate zone
- determine energy cost for each calendar type in each climate zone
- extrapolate energy and cost projections from elementary schools to high schools
- prepare an analytical report of energy use and cost implications for each calendar together with other findings and conclusions

The methods used by the project team to accomplish the objective and tasks outlined above are the subject of this report.

THE PROJECT TEAM

The following organizations and firms assisted in this study:

Educational Facilities Laboratories, Inc.

Project Administrator - John R. Boice
Technical Director - Joshua A. Burns
Research Associate - Steve Bedford
Project Secretary - Lorna Paisley

Flack & Kurtz - Consulting Engineers

Robert Hadden
George Rainer

State Education Department - Division of Research

Gerald H. Wohlferd

Hendrick Hudson School District

William L. McNally

CHAPTER II

SELECTION OF THE SAMPLE SCHOOL

EFL DATA BASE

EFL has operated the Public Schools Energy Conservation Service (PSECS) since 1975. Since that time, some 218 New York State elementary schools have been analyzed using various EFL computer programs. Information on 123 of these elementary schools was obtained as a part of the EFL study of New York State schools for the New York State Research and Development Authority.

The 218 schools in the EFL data base comprise 7 per cent of the total number of elementary schools in New York State. For purposes of this study, the schools were classified according to the EFL generic classification system which uses age as the primary factor. A complete description of the generic classification system is presented as Figure 1. on page 5. Since there were so few schools in the E30 and 32 classes, less than 10 per cent, it was decided to eliminate them from consideration. Further analysis of the E10's and E20's convinced the project team that a model of an E20 plant would provide the best example for purposes of this study.

The following characteristics were examined in each of the 102 - E20 schools:

- date of construction
- number of stories
- special facilities present
- type of meal service
- amount of glass in classrooms
- type of mechanical system
- control systems
- domestic hot water source

The typical building had the characteristics shown in Table I.

FIGURE 1

PSECS GENERIC TYPE DESCRIPTIONS

Types 10 and 12 - Pre-World War II Plants

Type 12 has mechanical cooling and 10 does not.

Dates of completion:	1920 to 1940
Plan type:	Double-loaded corridor.
Construction:	Heavy frame and walls.
Heating & Ventilating systems:	Hot water or steam boiler Radiation type systems (Some unit vents) Low speed fan.
Fuel (N.Y. State)	Typically oil and natural gas.
Lighting:	Original incandescents now largely replaced with fluorescents.
Classroom glass:	40 to 60% of exposed wall.

Types 20 and 22 - Post-War ("finger plan") Plants

Type 22 has mechanical cooling and 20 does not.

Dates of completion:	1945 to present
Plan types:	Single or double-loaded corridor.
Construction:	Light frame (single-story) Heavy frame (urban and multi-story.)
Heating & ventilating systems:	Hot water boiler Unit ventilator or similar type systems.
Fuel (N.Y. State)	Typically mostly oil and natural gas; some electricity.
Lighting:	Incandescent (ring) or early fluorescent now largely upgraded to fluorescent.
Classroom glass:	Up to 90% of exposed wall.

Types 30 and 32 - Artificial Environment Plants

Type 32 has mechanical cooling and 30 does not.

Dates of completion:	About 1965 to present
Plan type:	Compact
Construction:	As Type 20
Heating & ventilating systems:	Sophisticated air-handling types, such as single or double-duct, multizone, variable air volume, etc.
Fuel (N.Y. State)	All electric, natural gas and oil.
Lighting:	High level fluorescent.
Classroom glass:	Less than 15% typical of exposed wall.

TABLE I

CHARACTERISTICS OF THE
TYPICAL E20 ELEMENTARY SCHOOL

CHARACTERISTIC		% OF TOTAL
Size	53,900 sq ft	
Built	1965	54
Number of Stories	1	70
Gym	Yes	88
Auditorium	Yes	41
Meal Service	Yes	71
% of Glass	40 - 80	62
Unit Ventilators	Yes	64
Hot Water Boilers*	Yes	49
Setback	Yes	74
Source of Domestic Hot Water	Heat Exchanger	58

* Steam boilers were almost as commonly used (46%).

By matching these characteristics with the 102 - E20 schools in the data base, twelve schools with profiles similar to the model were selected for further study. The PSECS Audits on these twelve schools further reduced the number of candidates to four. These four were visited by the EFL team to determine their suitability to serve as the model for the energy analysis. The Furnace Woods School in the Hendrick Hudson District was selected to serve as the validation model. A comparison of the model with this school is shown in Table II.

TABLE II

A COMPARISON OF ACTUAL AND DERIVED MODEL SCHOOLS

	SIZE	BUILT	# STORIES	GYM	AUD	FOOD	GLASS	MECH	DHW
MODEL	53,900	1965	1	x	x	x	40-80	UV/HB	HE
FURNACE WOODS	47,900	1966	1	x	x	x	45	UV/HB	HE

The Hendrick Hudson District has participated in both the Phase I and Phase II studies being conducted by EFL for the New York State Energy Research and Development Authority. The data available on this facility, and the excellent cooperation of the district were a determining factor in the selection of this school as the calibration model.

CHAPTER III

COMPUTER SIMULATION OF THE CALENDARS

INTRODUCTION

Computer analysis of the energy implications of the nine calendars required simulation of the typical school in two stages. In the first stage, the Furnace Woods School was processed through a major engineering computer program to validate both the data on the school and the scheduling factors in EFL's Monthly Comparison Report, Version 1, program (MCR1). In the second stage, the MCR1 Program was used to simulate the performance of the typical school on each of the nine calendars in four climates.

The Monthly Comparison Report (MCR1) Program, developed by EFL as an extension to the PSECS Guideline Analysis Program (GAP3), requires six types of information about each school to prepare a monthly energy use analysis. These six types of information are:

1. Daily maximum and minimum temperatures for the month under study
2. A calendar for the current school year indicating full and partial school days, holidays and weekends
3. The typical daily hours of operation for the school
4. A set of energy use factors for the school produced by the GAP3 Program
5. A one-year history of energy use at the school
6. Utility rate structures for fuel and electricity

In preparing this study, detailed attention was paid to the collection or development of data in the first four categories. The following sections will describe the work done to prepare each of these items. As no actual school in each climate was being simulated, historical energy data was not required. Utility rates of $0.05 per KWH for electricity and $0.40 per gallon for #4 fuel oil were assumed.

Daily Weather Data and the Selection of Climates

The MCR1 Program requires daily temperatures for each month of analysis. This information is readily available in the form of monthly weather digests published by the U.S. National Oceanic and Atmospheric Administration (NOAA) for each State. The weather problem for this study therefore became one of (a) selecting weather stations with climates typical of various regions of New York State and (b) selecting a typical weather year for each of these stations.

An analysis of the 64 NOAA reporting stations in New York State for which long-term records are available indicated that the average number of heating degree-days during the year in the State is 6,988, with a maximum of 9,168 (Gabriels), and a minimum of 4,848 (New York Central Park). Statistically, two-thirds of the stations should fall within the range of 5,938 to 8,038 heating degree-days per year. Therefore, a selection of three stations at or near 5,900; 7,000 and 8,000 heating degree days was made. The areas selected included Bedford, Albany and Massena. As the stations selected were all in the eastern portion of the State, a fourth station, Buffalo, was added to provide information about climatic variation in western New York. Detailed degree day information is itemized in Table III.

The next step was to determine a "typical" weather year for each of these stations. Heating degree-days comparisons were made for the last ten year's data at each station and a typical year selected for each. These selections and the appropriate degree days are also itemized in Table II. As the MCR1 Program rounds differently than the NOAA program, the EFL degree-days are slightly different from the NOAA degree-days for the same period.

TABLE III

NEW YORK WEATHER STATIONS USED IN SIMULATIONS

Station	30-Year Norm DDH	Typical Year			
		Fiscal	NOAA DDH	EFL DDH	EFL DDC
Albany	6888.	73-74	6936.	7038.	626.
Bedford	5732.	72-73	5684.	5924.	734.
Buffalo	6927.	67-68	6921.	6940.	569.
Massena	8237.	76-77	8237.	8243.	456.

DDH = heating degree-days (NOAA definition)
DDC = cooling degree-days (NOAA definition)

Preparing the Nine Calendars for Processing

The preparation of MCR1 calendars required the translation of the nine calendars provided by the State Education Department into a form acceptable by the MCR1 program. (See appendix for calendar descriptions.) This required the development of a simple classification system for various daily uses patterns. Five types of school days were defined, four of which were used in this study. These included:

- 0 = Regular Day
- 1 = Holiday or Closure Day
- 2 = Half Day
- 3 = Saturday or Sunday
- 4 = Summer Session (Not used in this study.)

In making the analysis, the extra days allotted to making up snow and other closures, were treated as school days for all calendars. As the MCR1 program does not recognize leap-year, only 28 days were allowed in February.

To determine the actual daily energy use for each type of day identified in the preceeding section, the MCR1 makes use of information which describes the schedule of educational and other activities on the one hand, and the operation of the plant to serve these activities on the other.

Daily Activity Schedule

In order to make the various calendars as comparable as possible, only regular school day sessions were assumed for the typical school. No evening, weekend, or summer school activities were considered. Summer school is defined as an activity different from summer operation under a year-round program. The auditorium space of the school was scheduled for three hours of academic use per class day, while gymnasium and classroom type spaces were operated either 5.5 hours per day (Calendars 1,2,3,4,7,8,9) 6.0 hours per day (Calendar 6), or 7.5 hours per day (Calendar 5). To these hours were added one morning hour for building preparation and one hour in the afternoon for building clean-up.

Spaces in the school were assumed to be totally utilized with an average classroom load of about 25 students. This resulted in an average daily attendance of 600 students, with 450 hot lunches prepared for them. Classrooms were assumed to be empty about one hour per day to allow for lunch, recess, and other periods when students are in other building spaces.

Plant Operating Assumptions

The underlying plant operating assumptions for this study were that the staff of the school would operate it in a well-informed but not necessarily rigorously energy conservative manner. While these assumptions produce a school which is more efficient in its energy use than those typically encountered, the resulting levels of performance can be achieved by virtually any school which makes the effort.

Space temperatures in the school are consistent with those recommended by State and Federal agencies. Daytime temperatures in the classrooms are 68 F, in the gymnasium and auditorium 65 F. Overnight setback temperatures are 55 F for all spaces. Lights are assumed to be turned off when spaces are not in use, and often when there is sufficient daylight to do without them.

The principal energy effect of the assumption about well-informed operation is seen during extended periods of closure. Many people seem to feel that when the plant is not occupied for extended periods, such as Christmas vacation or one of the longer vacations on the various calendars, that all energy use of the plant can be eliminated. In a climate such as that of New York, this is not a realistic view, unless very expensive and difficult procedures of school closure are undertaken. More than the goldfish can freeze over the Christmas break. Additional savings may result if extensive closure procedures are followed, but their magnitude and cost-benefits are beyond the scope of this study.

This study takes the alternate position that the operations of the school during extended closures would be reduced to a minimum level consistent with building protection. This is essentially expressed in longer periods where building space temperatures are kept at 50 F. Reduction below this temperature would not result in any great additional savings. Additionally, the boiler is assumed to be turned on if there is any reason to anticipate temperatures below 40 F during the closure, and left on for the period of the closure. This approximates reasonable performance, without the addition of any sophisticated freeze-protection controls and alarms. Since they are not used for service hot water, boilers are not turned on prior to October 15th, or left running after April 5th.

School Plant Energy Use Factors

Using the data collected on the Furnace Woods School with PSECS form PS-4A, the GAP3 computer program was used to generate a set of factors which were then used by the MCR1 program to produce monthly energy use guidelines. These factors provide information on the amount of heat loss through the school shell; the heat required for treating outside air introduced into the spaces, both intentional and incidental; the amount of energy used by the lights and other systems, including fans and pumps; and various aspects of the operation of the boilers.

Prior to processing the Furnace Woods School, however, various modifications were made to the data to reflect conditions more typical of New York schools. The principal modifications included were:

- reduction of the size of the school's boilers by about 50%
- replacement of the school's high efficiency boilers with more commonly encountered types
- addition of electric domestic hot water heaters to provide service hot water when the boilers were not fired for heating
- modification of the plant's ranges to use electricity in lieu of the natural gas actually used to eliminate the need to analyze a third type of energy

The effects of some of these modifications were simulated separately prior to modifying the typical plant to reflect all of these changes. Other options were also simulated to permit observation of the effects of modifications and characteristics, such as steam boilers or added cooling, not embodied in the "typical" school.

CHAPTER IV

RESULTS OF THE COMPUTER SIMULATIONS

The results discussed in this section were produced by processing the data described in the preceding section, through the MCR1 computer program. The results of these simulations are presented in Tables IV, V, VI and VII. These tables provide the basic information produced by this study. In the following section, a brief survey of the results will be presented. In this discussion, the possible advantages and disadvantages of Calendar #9, the 45-15 Rotation Year Round option, will be discussed separately.

Tables IV and V present the basic results in the form of the MCR1 simulation of total annual energy use and costs. As would be expected, usage of fuel oil and related fuel costs increase as one goes from the mildest climate (Bedford) to the most extreme (Massena). For the traditional calendar (#1), the increase of about 38 per cent in fuel oil use, approximates the increase in heating degree-days. Climatic variations in elctrical usage among the calendars were not considered significant.

Tables VI and VII present the results as percentage variations from the traditional calendar in each climate. With the exception of #9, all of the variations result in some energy and cost savings over the traditional. The magnitude of these changes, however, is small with only one calendar, #5, producing more than a ten percent change in all climates. The major reason for this calendar's advantage, is the fewer number of days on which the plant is used. This means fewer meals, less hot water and less morning warm-up in the winter.

TABLE IV

ENERGY USE COMPARISON OF NINE PROPOSED CALENDARS

IN FOUR NEW YORK CLIMATES

Calendar	Electric KWH All	#4 Fuel Oil Gallons			
		Albany	Bedford	Buffalo	Massena
#1 Traditional	210384.	21734.	18696.	21231.	25881.
#2 Ten-month Year	210384.	21331.	18253.	20812.	25064.
#3 Mid-August Start	210384.	21221.	17910.	20629.	24856.
#4 Four-day Week	210384.	20154.	15972.	19565.	23648.
#5 Four-day 7.5 Hr.	185481.	19591.	16353.	18989.	23104.
#6 Four & Five Day	204449.	20310.	17410.	19821.	24128.
#7 12-month	210384.	20604.	17657.	20047.	24407.
#8 5 Inst. Pds.	205583.	20765.	17725.	20436.	24461.
#9 45-15 Rotation	273844.	21990.	18984.	21461.	25824.

TABLE V

ENERGY COST COMPARISON OF NINE PROPOSED CALENDARS

IN FOUR NEW YORK CLIMATES

Calendar	Albany	Bedford	Buffalo	Massena
#1 Traditional	$ 19213.	$ 17997.	$ 19011.	$ 20871.
#2 Ten-month Year	19051.	17820.	18844.	20545.
#3 Mid-August Start	19007.	17683.	18771.	20461.
#4 Four-day Week	18581.	16908.	18345.	19978.
#5 Four 7.5 Hour Days	17110.	16908.	18345.	18516.
#6 Four and Five Day	18346.	17186.	18150.	19873.
#7 Twelve-month Year	18761.	17582.	18538.	20282.
#8 Five Instr. Periods	18585.	17369.	18453.	20063.
#9 45-15 Rotation	22488.	21286.	22276.	24022.

Cost estimates based on electrical cost of $0.05 per KWH, #4 fuel oil at $0.40 per gallon.

TABLE VI

PERCENTAGE VARIATION FROM TRADITIONAL CALENDAR

ENERGY USAGE IN FOUR NEW YORK CLIMATES

Calendar	Electric	#4 Fuel Oil			
	All	Albany	Bedford	Buffalo	Massena
#1 Traditional	0.0	0.0	0.0	0.0	0.0
#2 Ten-month Year	0.0	-1.9	- 2.4	- 2.0	- 3.2
#3 Mid-August Start	0.0	-2.4	- 4.2	- 2.8	- 4.0
#4 Four-day Week	0.0	-7.3	-14.6	- 7.8	- 8.6
#5 Four 7.5 Hr. Days	-11.8	-9.9	-12.5	-10.6	-10.7
#6 Four and Five Day	- 2.8	-6.6	-.6.9	- 6.6	- 6.8
#7 Twelve-month Year	0.0	-5.2	- 5.6	- 5.6	- 5.7
#8 Five Instr. Pds.	- 2.3	-4.5	- 5.2	- 3.7	- 5.5
#9 45-15 Rotation	+30.2	+1.2	+ 1.6	+ 1.1	+ 0.2

Entries with a "+" sign indicate usage increases over #1, those with a "-" indicate usage decreases over #1.

TABLE VII

PERCENTAGE VARIATION FROM TRADITIONAL CALENDAR

PER PUPIL ENERGY COSTS IN FOUR NEW YORK CLIMATES

Calendar	Albany	Bedford	Buffalo	Massena
#1 Traditional	0.0	0.0	0.0	0.0
#2 Ten-month Year	- 0.8	- 1.0	- 0.9	- 1.6
#3 Mid-August Start	- 1.1	- 1.7	- 1.3	- 2.0
#4 Four-day Week	- 3.3	- 6.1	- 3.5	- 4.3
#5 Four 7.5 Hour Days	-10.9	-12.1	-11.3	-11.3
#6 Four and Five Day	- 4.5	- 4.5	- 4.5	- 4.8
#7 Twelve Month Year	- 2.4	- 2.3	- 2.5	- 2.8
#8 Five Instr. Periods	- 3.3	- 3.5	- 2.9	- 3.9
#9 45-15 Rotation				
A 600 enrolled, 450 ADA	+17.0	+18.3	+17.2	+15.1
B 800 enrolled, 600 ADA	-12.2	-11.3	-12.1	-13.7
C 800 enrolled, 600 ADA (Air Cond.)	- 6.3			

Except for Calendar #9, all per pupil costs are based on 600 ADA students. Costs are based on electricity at $0.05 per KWH, #4 oil at $0.40 per gallon. Positive figures "+" indicate increases over Calendar #1, negative figures "-" indicate decreases from Calendar #1.

EFL experience suggests that these energy changes are not particularly significant. This is especially true when compared to the energy savings which can be made in most schools by simple operating and maintenance changes to get to the "well-informed" operation level, at which point this study begins, or when compared to savings possible with some simple and basic building modifications, such as the separate service hot water heaters included in our typical school model.

Analysis of the results for Calendar #9, the 45-15 Rotation variant, poses some problems. If analyzed as a typical school housing 600 students, this calendar produces significant increases in electrical use and energy costs over the traditional. However, if this plant has a daily attendance of 600, it is actually handling the educational needs of 800 students per year, so the per pupil energy costs are significantly lower. In fact, on this basis, this calendar is the most energy efficient in three of the four climates.

Adding Cooling to the Typical School

The calendars which extend the school year into the high summer months may necessitate mechanical cooling of the school building for user comfort. Such cooling would increase the energy use and costs associated with these calendars. To obtain some idea of the magnitude of this effect, one of the calendars was investigated in one climate. The 45-15 option which makes most use of the plant during the summer was simulated for Albany, (626 cooling degree-days.)

To simulate the effect of added cooling, the description of the typical school was modified to reflect the installation of a chiller and its accessories. These changes simulate the operation of a 150 ton centrifugal chiller with an air-cooled compressor. This chiller feeds chilled water through the same pipes used to distribute hot water to the school's classroom unit ventilators, when heating is required.

Such a system offers the option of either heating or cooling, and would require something in the nature of a $75,000 to $125,000 investment.

Simulating the operation of the now heated and cooled school with summer space temperatures set to 78 F, indicated an additional electrical usage of about 30,333 KWH, costing about $1,517. The resulting total figures for Calendar #9 in Albany are:

- total electric	304,177 KWH	$ 15,209.
- total oil	21,990 gals	$ 8,796.
- total billings		$ 24,005.

This represents a 44.6 per cent increase in electrical consumption and a total cost increase of 24.9 per cent over the traditional calendar. The per pupil cost, based on 800 students served, would actually be about 6 per cent less than under the traditional schedule.

This study assumes that the energy use effects of cooling on the calendar with the most summer use in the average climate, reflects the average effect of such change. In the other calendars, which make less use of the plant in the summer, and in the other climates, the effect would be correspondingly smaller.

CHAPTER V

OBSERVATIONS

A number of additional observations, based on the work done in the simulation of the selected school and extending this work to other school types, were included as a part of the work of this study. These observations are narrative in nature, and are not based on actual simulations of other buildings.

Calendar Effects on Energy Use in Other Elementary School Types

1. As has been mentioned in preceding sections, the typical school used for simulation purposes was selected because it represented a large block of similar schools in the State, according to EFL data. Another almost equally large block comprises schools built prior to World War II. These can be characterized as multi-story, heavy frame schools with radiators and steam boilers.

For several reasons, EFL believes that the energy effect of calendar changes in these schools would be considerably less marked than in the finger plan plant of this study. Foremost among these reasons is, that for the most part these schools use less energy at guideline levels to begin with, than do the finger plans. Other factors, including greater heat retention by the heavier buildings, lower lighting levels and fewer boiler accessories, support this view.

Of the remaining schools, a number are of the modern artificial environment type with greatly reduced glass areas and sophisticated heating and, in many cases, cooling systems. These plants represent somewhat of an enigma in general, as they appear to be the most potentially efficient schools to operate,

but EFL rarely has encountered one operating even vaguely near its potential efficiency. The effect of calendar change in these schools will more than likely be similar to that of the mechanically cooled typical school reported in this study. However, if the plant can be operated at guideline efficiency, the result would be slightly smaller differences among the calendars.

Effect of Calendar Change in High Schools

2. In considering the likely effect of calendar change in secondary schools, it will be useful to divide these schools into two classes. In the first class, high schools with largely academic programs and little use other than for standard class day, one would expect that the statements pertaining to elementary schools would hold true. The magnitude of differences among calendars should change by the ratio of the size of the secondary school to the size of the typical elementary school.

In the other class, for secondary schools with extensive specialized facilities (shops, gyms, swimming pools) and/or extensive out of regular school day use, the situation is not so clear. All of these features would tend to reduce the differences between calendars, but the exact effect would probably depend to a large part on the specifics of each case.

Some Final Observations

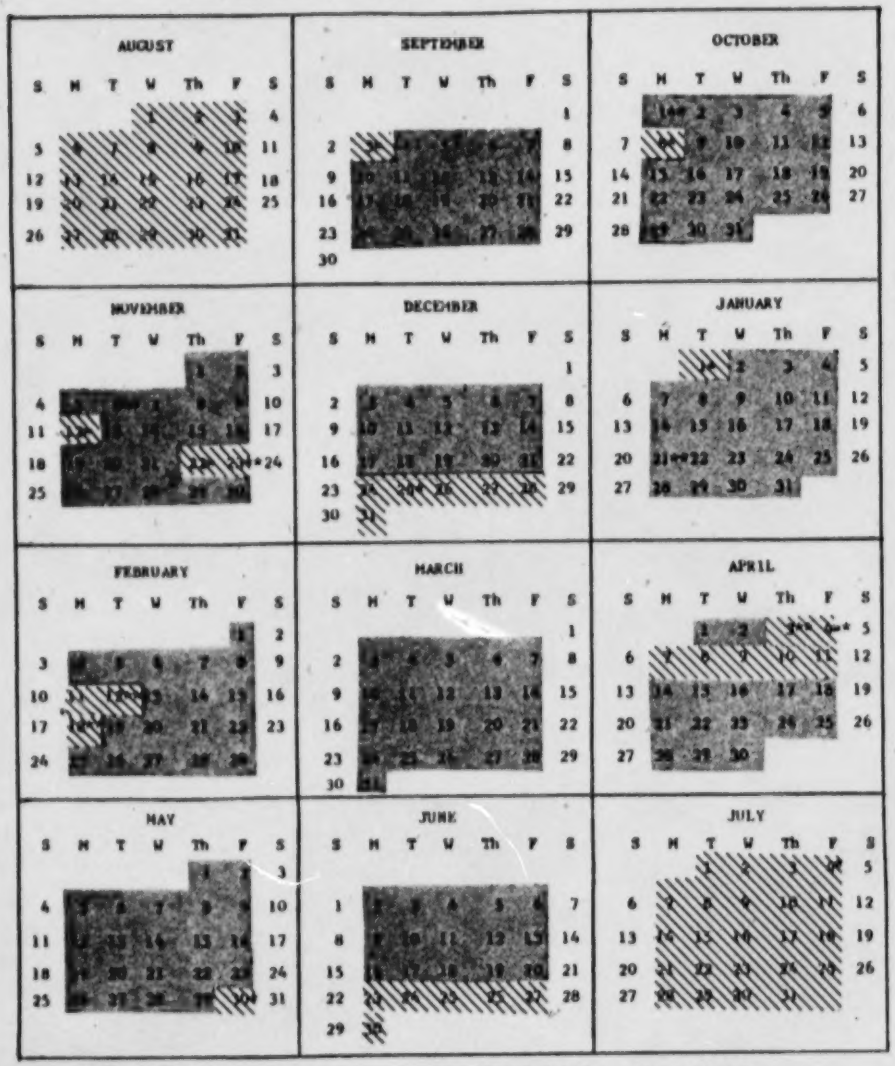
3. The most economical schedules, from an energy use standpoint, are those that require the operation of the school for the fewest number of days at regular temperatures during the heating season, and provide the most vacation or shut down periods of three or more consecutive days.

Calendar #5 is an example of such a schedule. In this schedule there are only 136 - 7½ hour class days, 4 days per week; thus allotting 3 days per week at minimum temperatures.

Given the slight differences between the various calendars observed in this study, it would be difficult to make a strong case for one calendar over the others on the basis of its energy saving potential.

APPENDIX A

OPTION #1 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
A CONVENTIONAL SCHOOL YEAR CALENDAR,
ONE WITH NORMAL WINTER AND SPRING VACATIONS

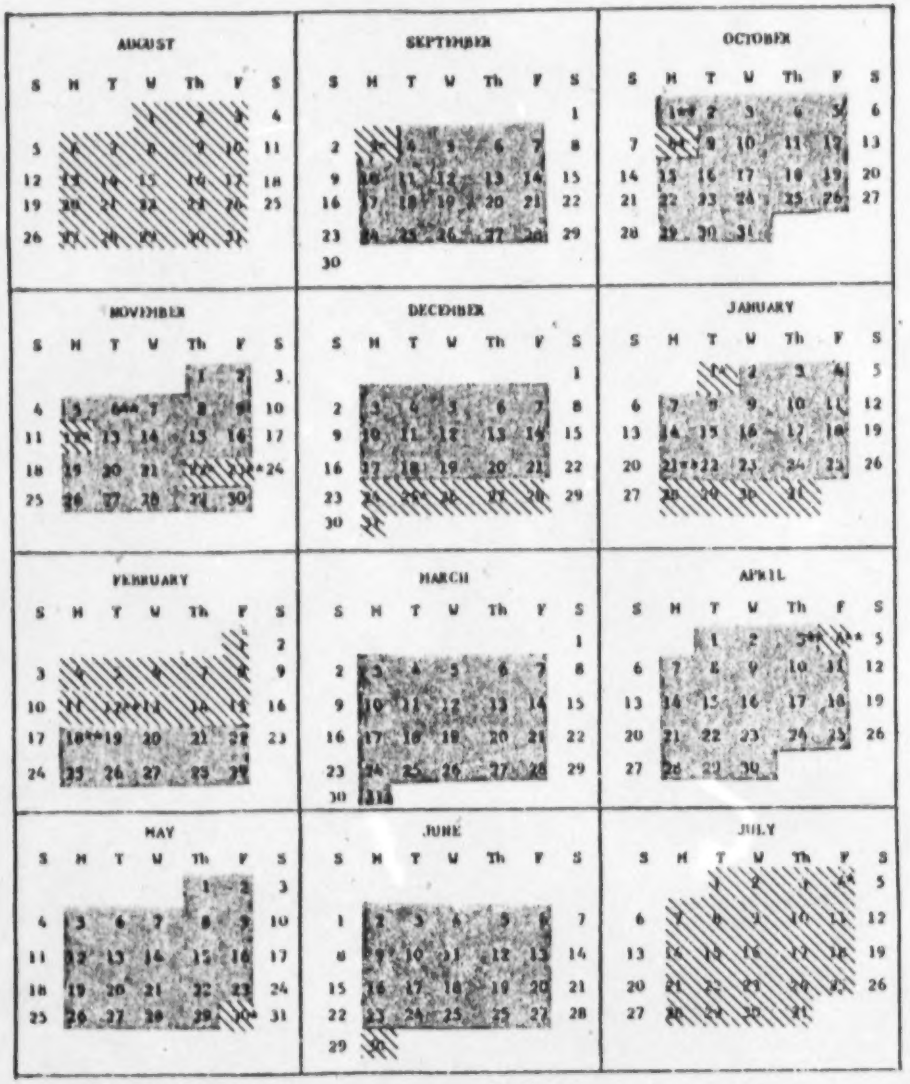


Special Characteristics:

The traditional school calendar is illustrated here. School begins the day after Labor Day (September 4, 1979) and ends in mid-June (June 20, 1980). All legal holidays, Christmas and Easter vacations, and a ten-week summer vacation are included in the calendar. There are four vacation days scattered in October and November plus a seven-day vacation during Christmas through New Years Day. There are also three vacation days in February and one in May, plus a combined Easter-spring vacation of seven days. The 187 days of this calendar allow option of more vacation days if the seven emergency closing days are not anticipated to be used.

APPENDIX B

OPTION #2 - EXPERIMENTAL ALTERNATIVE SCHOOL CALENDAR
TEN-MONTH REGULAR SCHOOL YEAR WITH SPECIAL CLOSING AT MID-YEAR

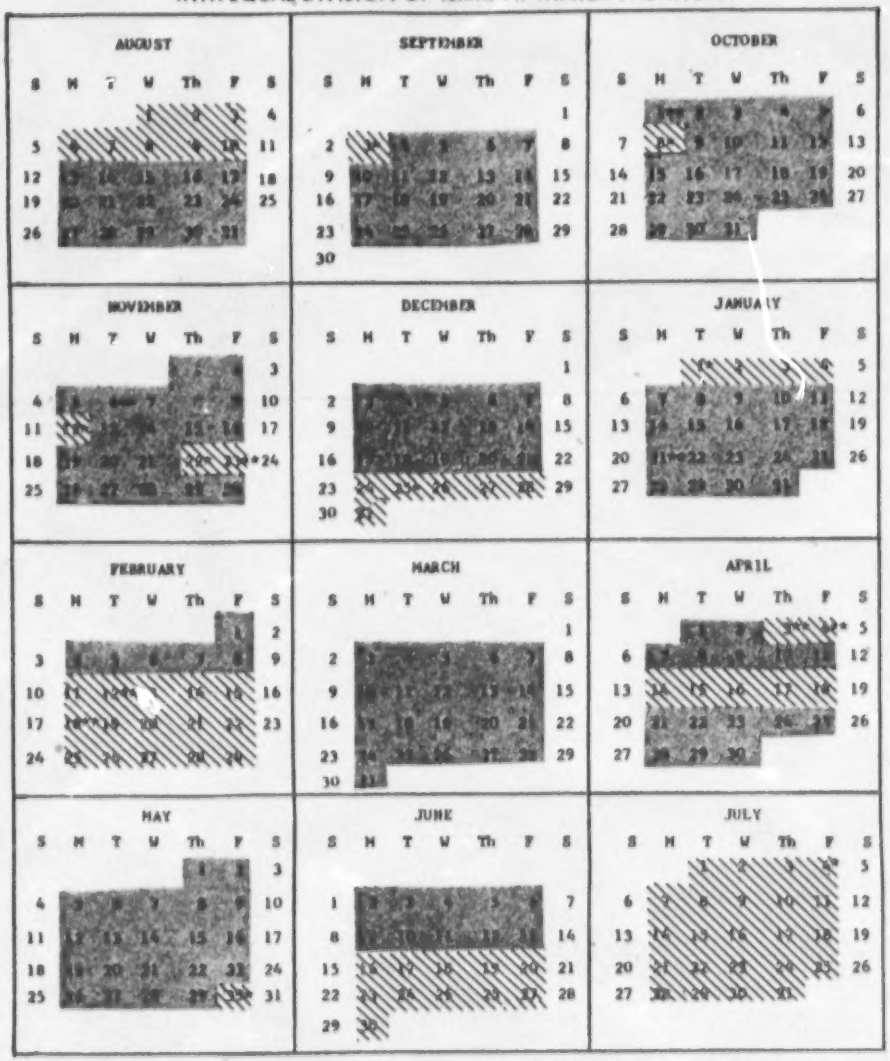


Special Characteristics:

This calendar, though quite similar to the traditional calendar (Option #1), is designed to close schools during the colder part of the winter. School begins on the day after Labor Day (September 4, 1979) and operates through the end of June (June 27, 1980). All legal holidays, a seven-day Christmas vacation, a 15-day mid-winter vacation and a nine-week summer vacation are included. There are no Easter or spring vacations. The mid-winter vacation has balanced 93-day semesters surrounding it. The first semester has four vacation days throughout October and November, providing two three-day weekends and one four-day weekend. The second semester has two vacation days, one in April and one in May, providing two three-day weekends. The 186 days of this calendar allows for six emergency closings. Variations in this calendar may be provided by minor vacation shifts.

APPENDIX C

OPTION #3 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
MID-AUGUST START, TWO-SEMESTER CALENDAR
WITH EQUAL DIVISION OF TERMS AT WINTER VACATION

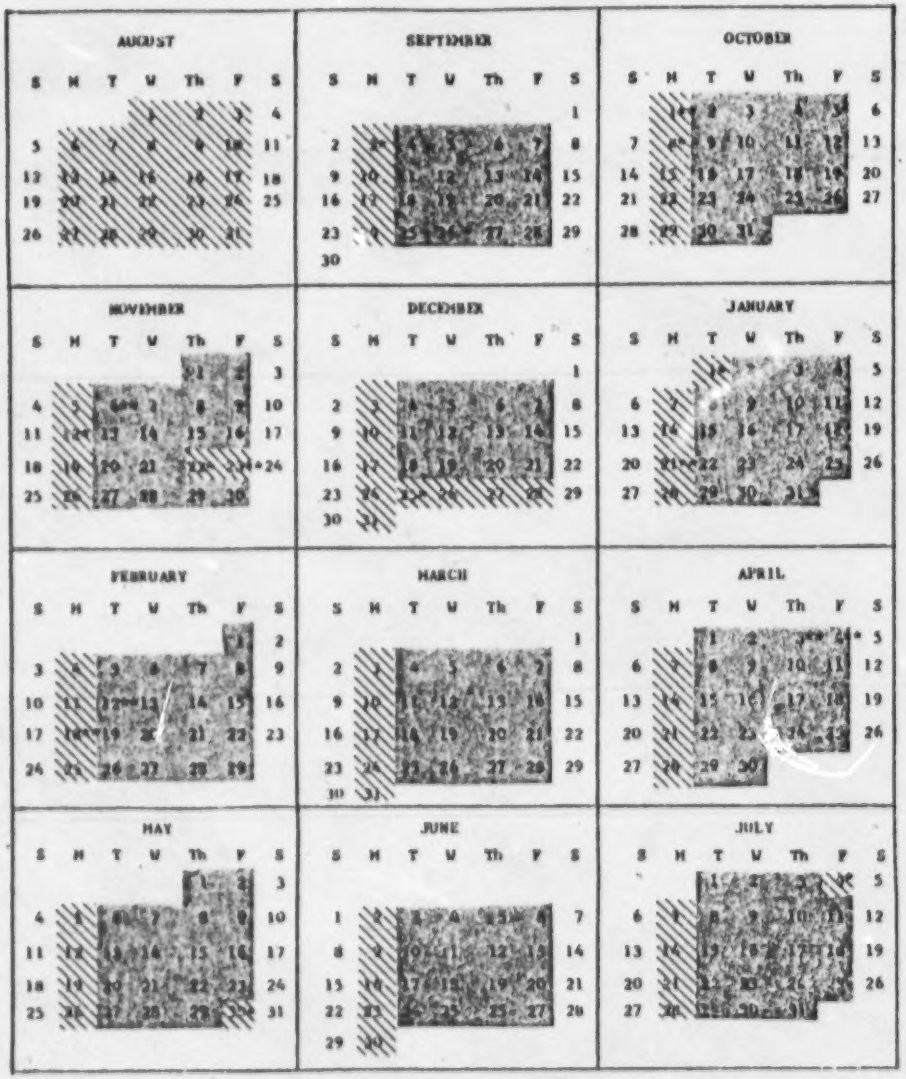


Special Characteristics:

In order to provide approximately equal numbers of days before and after the Christmas vacation, school must be started earlier. Thus, this calendar school starts in mid-August (August 13, 1979) and ends in mid-June (June 13, 1980). All legal holidays, three special holidays, a ten-day Christmas vacation, a 15-day February vacation, and a five-day April vacation are included. There are 90 days of instruction before the Christmas vacation and 92 days in the second semester. This calendar of 182 days provides for only two emergency closing days. Some adjustments might have to be made in vacation days for those districts needing more emergency closing days.

APPENDIX D

OPTION #4 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
FOUR-DAY WEEK CALENDAR, WITHOUT TIME EQUALIZATION, WITH
A ONE-WEEK WINTER AND A FULL MONTH SUMMER VACATION



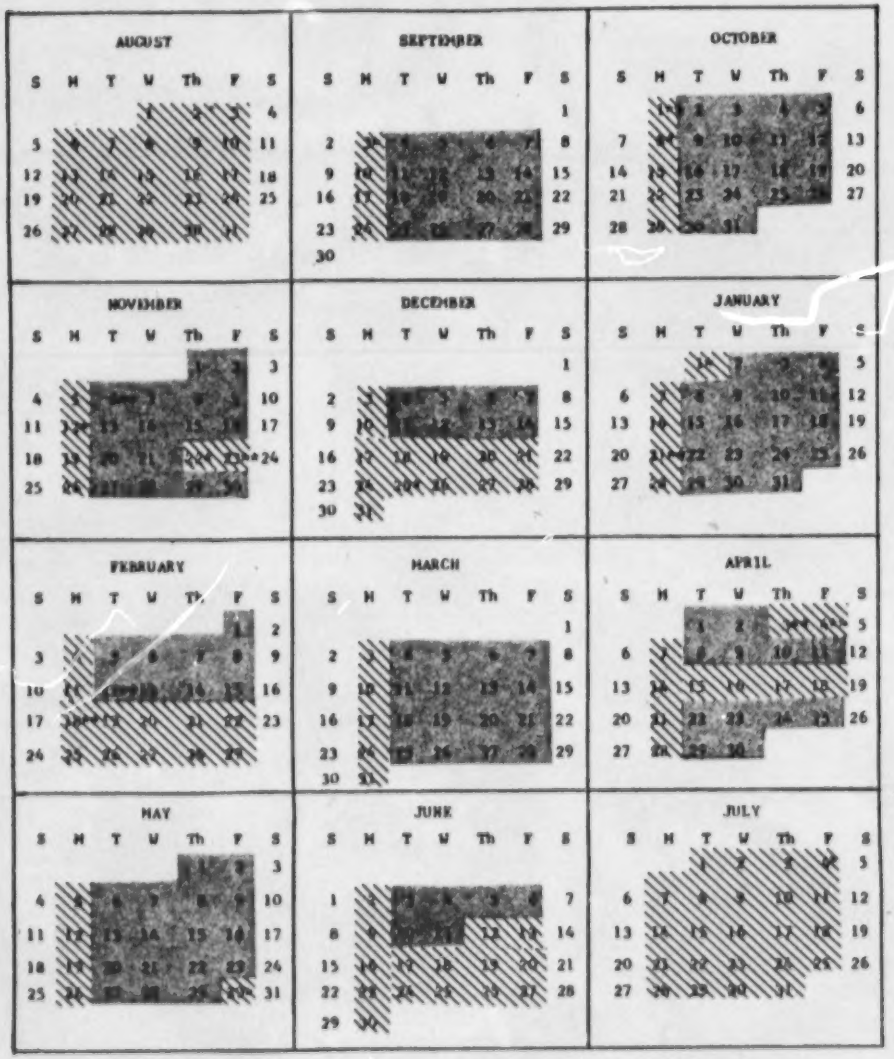
Special Characteristics:

In this type calendar, school is in session for four days a week for 5¼ hours a day. There is a three-day weekend. Though this illustration shows Monday as the day off, Friday could be substituted to yield the three-day weekend. In order to meet the mandated 180 days of school at 5¼ hours, the school year must run into the summer months. The calendar could be adjusted so that July rather than August would be the vacation month for some school districts.

In this illustration, school starts the day after Labor Day (September 4, 1979) and goes through July 31, 1980. All Mondays and holidays are either extended weekends or vacation days. A four-day vacation at Christmas and a month vacation period in August are included. The 183 instruction days provide for three emergency closings.

APPENDIX E

OPTION #5 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
A FOUR-DAY WEEK CALENDAR WITH TIME EQUALIZATION FOR A SEVEN AND ONE-HALF HOUR DAY WITH TWO WINTER VACATIONS PLUS ONE SPRING VACATION

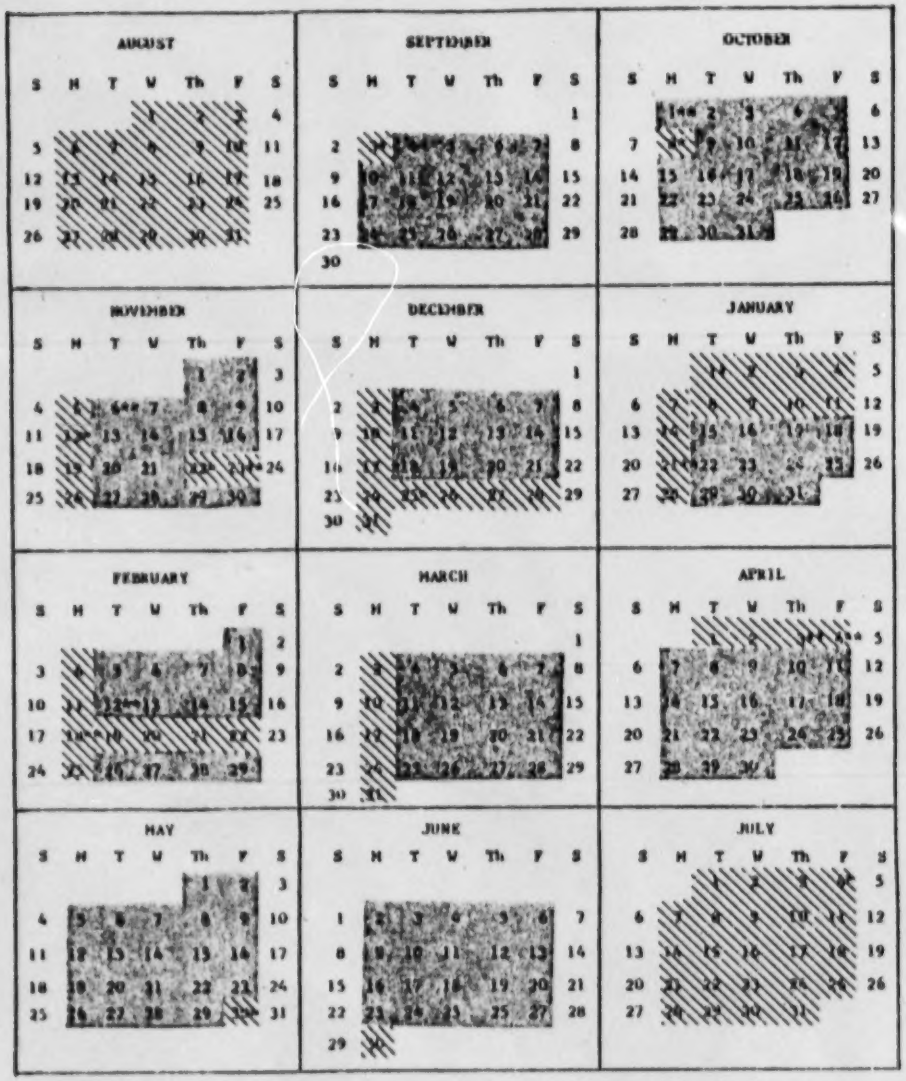


Special Characteristics:

This calendar is designed to give a four-day school week with a three-day weekend, and retain the summer vacation. The school day is lengthened to 7½ hours to yield approximately the same total number of instructional hours per year as contained in the traditional calendar. School begins on the day after Labor Day (September 4, 1979) and ends in mid-June (June 11, 1980). All Mondays, all legal holidays, six special holidays, plus two winter vacations at Christmas and in February, and one spring vacation are included as non-attendance days. The 136 days of school at 7½ hours per day provide 1,020 hours, enough above the traditional 990 hours to allow for four emergency closing days. Friday closings could be substituted for Monday closings.

APPENDIX F

OPTION #6 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
A FOUR TO FIVE-DAY WEEK WITH TIME EQUALIZATION FOR A SIX-HOUR DAY



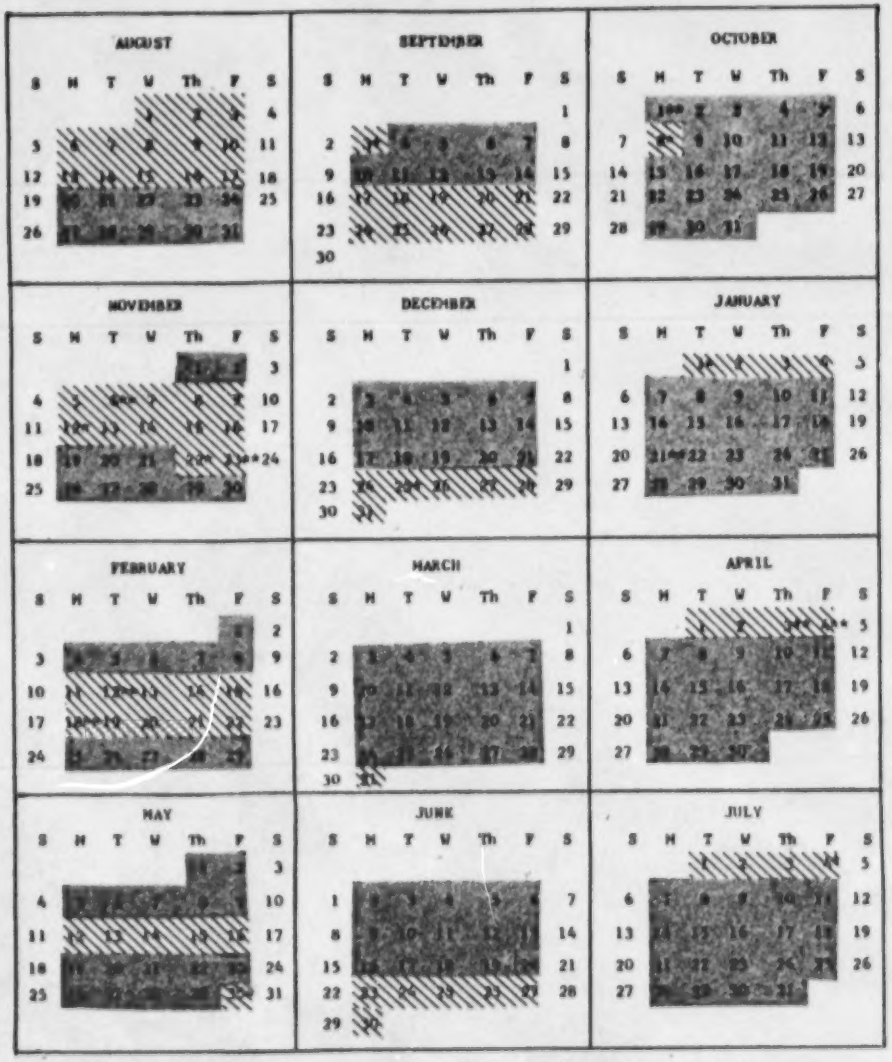
Special Characteristics:

This calendar is constructed to permit a longer weekend closing during the colder months, while maintaining the traditional five-day week during warmer months and also retaining the traditional summer vacation.

School begins on the day after Labor Day (September 4, 1979) and goes to the end of June (June 27, 1980). School is in session five days a week throughout the months of September, October, April, May and June. During the months of November through March, there are no sessions on Mondays, although Friday closings could be substituted for Monday closings. In addition to the legal holidays, there are three extended vacations: 12 days at Christmas time, four days in February, and four days at Easter time. In order to preserve a full two-month summer vacation, the school day has been lengthened to six hours throughout the year. This yields 1,008 instructional hours, allowing for the equivalent of three emergency closings.

APPENDIX G

OPTION #7 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
A TWELVE-MONTH LEARNING YEAR CALENDAR WITH MULTIPLE VACATIONS

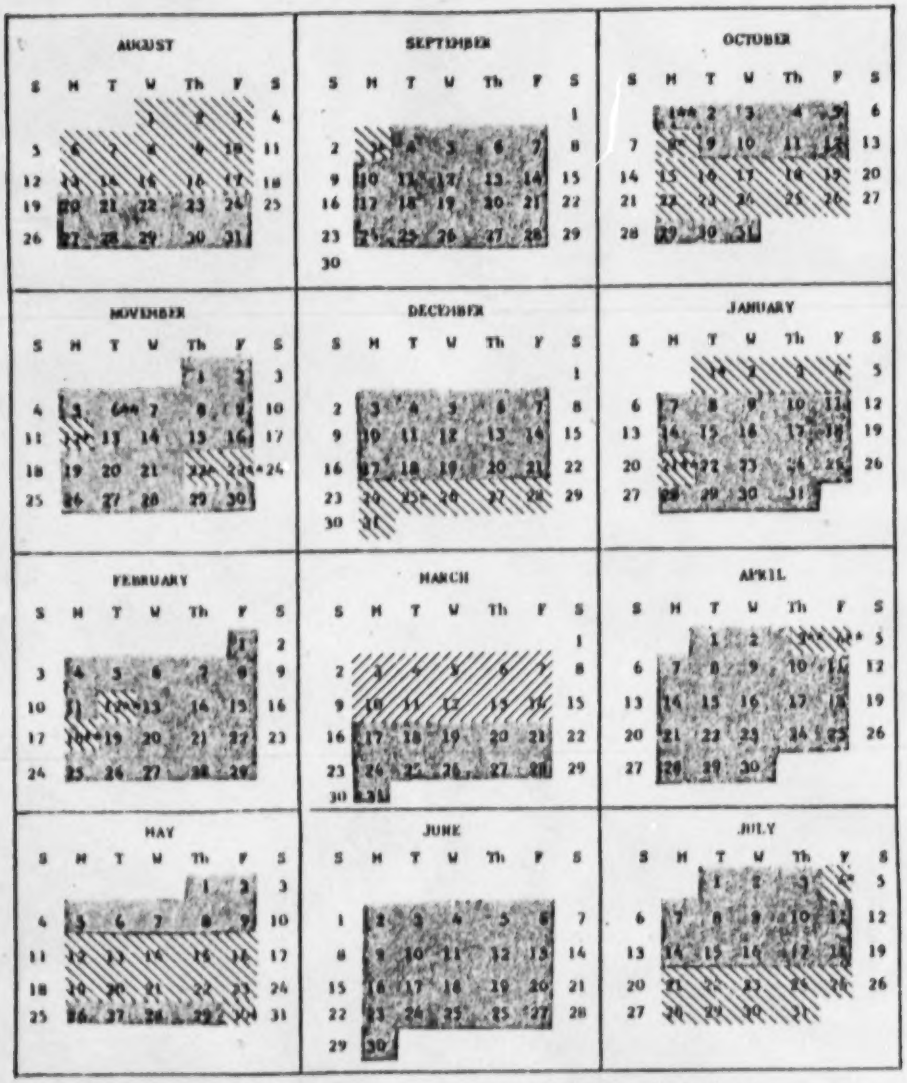


Special Characteristics:

This is a twelve-month school calendar. It is characterized by learning periods of four or five weeks duration separated by vacations of one through three weeks. The summer vacation of approximately three weeks is the longest vacation period. Those legal holidays which do not occur during normal vacation periods are observed as holidays. There are a total of 184 instructional days in the calendar.

APPENDIX H

OPTION #8 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
A CONTINUOUS LEARNING YEAR CALENDAR BUILT AROUND FIVE INSTRUCTION TIME PERIODS

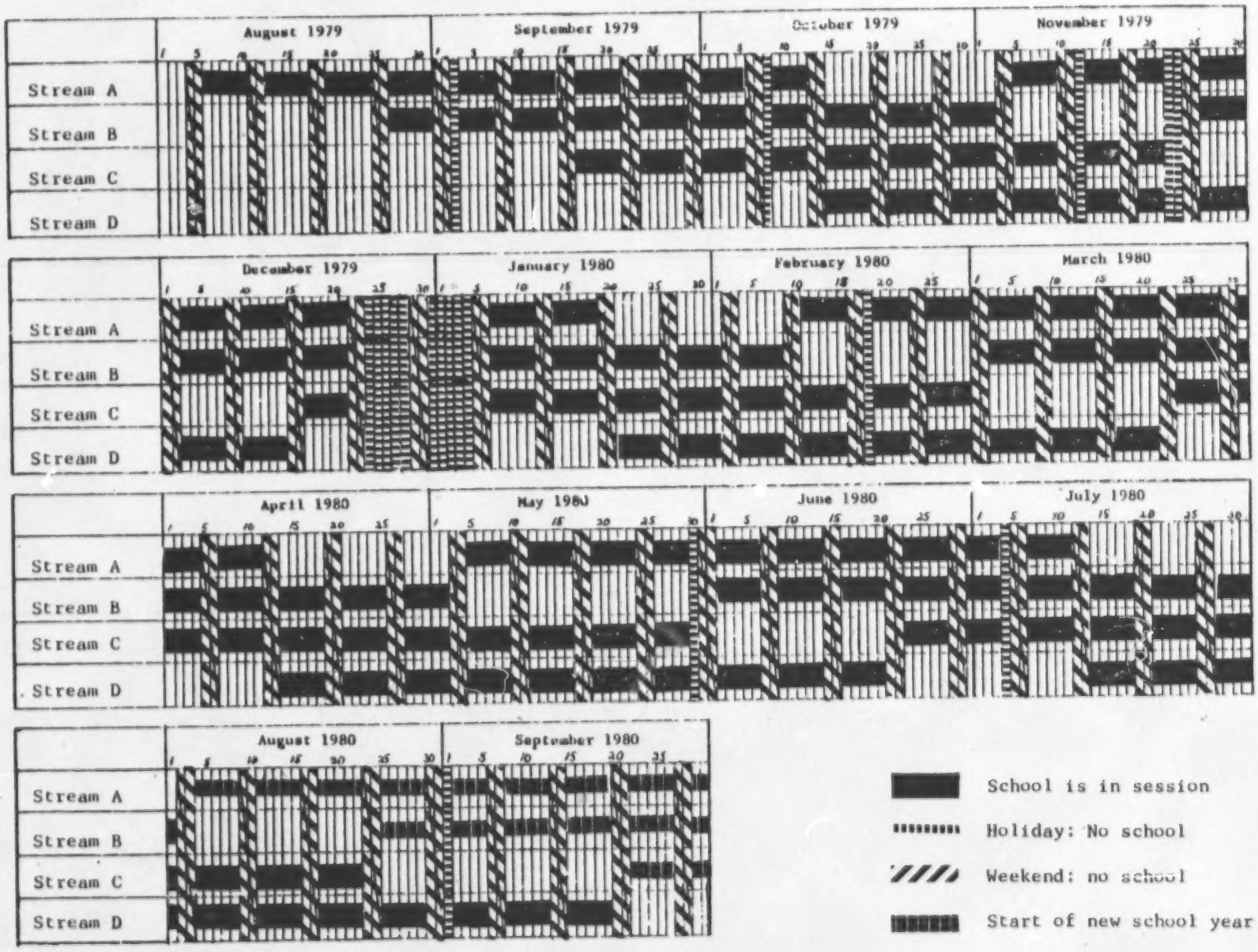


Special Characteristics:

This calendar, beginning in mid-August and ending in mid-July, is designed to give five eight-week learning periods separated by two-week vacations. A mid-summer vacation of four weeks is provided. Variations in summer starting and closing times will permit different summer vacation periods. The 188 instructional days in this calendar allow for several emergency closings.

APPENDIX I

OPTION #9 - EXPERIMENTAL ALTERNATIVE SCHOOL YEAR CALENDAR
FOUR STREAM, TERM ROTATION, ALL YEAR, BASED ON 45-15



Special Characteristics:

This calendar is representative of several types which divide the student body into groups so that some groups are in school while others are on vacation. In this illustrative calendar, students are assigned to one of four "streams" or groups of approximately equal size. The starting and ending times for the different streams are staggered such that, at any given time, three streams are in session and one stream is on vacation. Weekends, legal holidays, and the ten-day Christmas vacation provide the only common closings when all streams are on vacation at the same time. The calendar is cyclical and continuous, with approximately 45 days in session and 15 days on vacation (exclusive of weekends and holidays). There is no extended summer vacation. For the illustrative year, the total number of instructional days are 182, 182, 183, and 184 respectively for each of the four streams. Thus, there is allowance for two to four emergency closings. Minor variations in the format of the calendar are possible.